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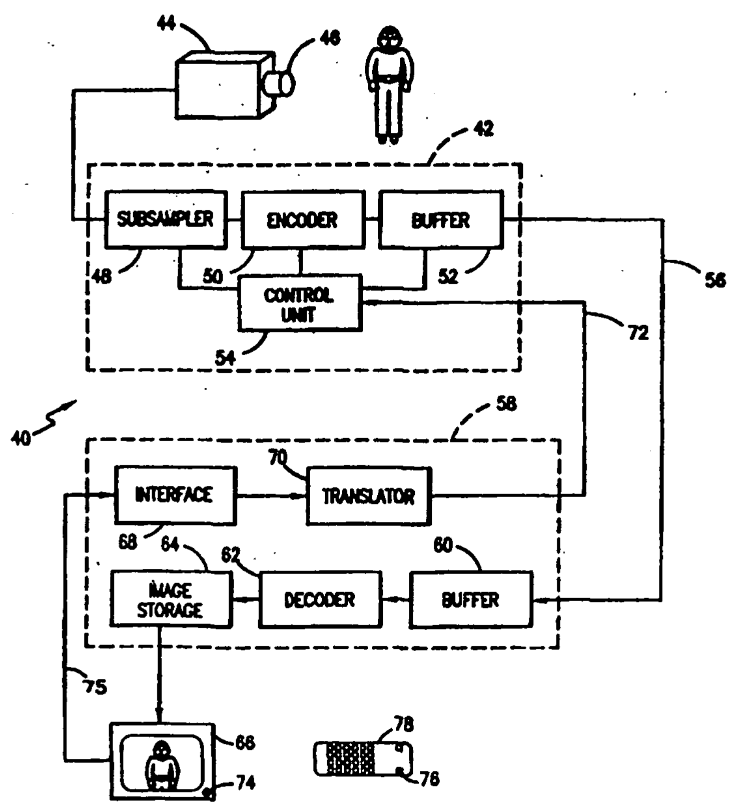
(54) Title: IMAGING SYSTEM AND METHOD FOR INTERACTIVE CONTROL OF IMAGE QUALITY

(57) Abstract

An improved imaging system (40) and method for providing increased viewer control over the operating parameters of the imaging system (40) is disclosed. Viewer control is facilitated by including a backchannel (72) within the imaging system (40), whereby a viewer may adjust spatial and temporal resolution, quantization and other operating parameters of the video transmission.



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IMAGING SYSTEM AND METHOD FOR INTERACTIVE CONTROL OF IMAGE QUALITY

BACKGROUND OF THE PRESENT INVENTION

Field of the Invention

The present invention relates generally to an electronic imaging system and method, particularly, to an improved imaging system and method for customizing the images to the viewer's specifications, and, more particularly, to an imaging system and method allowing the viewer, via a backchannel, to adjust the spatial and temporal resolution and quantization parameters of an image.

Background and Objects of the Present Invention

With the rise of the consumer electronics industry over the past few decades, a variety of electronic imaging systems of increasing complexity have emerged, e.g., video recorders, camcorders and the like. Additionally, video teleconferencing communications are becoming increasingly important as our society becomes increasingly and interactively interconnected.

As is understood in this art, video, i.e., moving, images undergo encoding to reduce the amount of information needed to represent a given image. Encoding affects both the spatial resolution, i.e., the detail within a particular image frame, and temporal resolution, i.e., the number of such image frames per second. These parameters are typically fixed within a conventional video system, such as the one shown in FIGURE 1 of the Drawings and generally referred to herein as numeral 10. The video system 10 in the figure includes a sending device 12 which receives signals from a camera 14. It should be understood that various portions of camera 14 which are not related to the present invention, for example, the diaphragm, shutter and the like, are not illustrated. Accordingly, as is understood in this art, the optical image before the camera 14, such as the individual depicted, is received by a camera lens 16 and converted into an analog video signal, e.g., by a conventional charge coupled device. It should be understood that camera 14 may be a digital camera

forwarding digital data to a subsampler device 18 within the sending device 12. If camera 14 is not digital, however, and analog-to-digital conversion is required, then device 18 may also function as an A/D converter, as is understood in the art. The subsampler 18 determines pixel values representing the captured video image at a particular spatial resolution, i.e., pixels per line and lines per image, and temporal resolution, i.e., images per second. Another parameter related to both spatial and temporal resolution is quantization, i.e., a measure of the amount of distortion present in the video signal, as will be discussed in more detail hereinafter.

An encoder 20 encodes the aforedescribed digital image data into a video signal stream which flows into a buffer 22. As is understood in the art and discussed further herein, the rate of the flow of information from the encoder 20 into buffer 22 varies in accordance with the degree of encoding. Additionally, the video signal stream typically includes compressed signals, in which image information has been condensed or compressed by the encoder 20 to facilitate transmission or storage. One set of formats using such compression technologies are those specified by the Moving Picture Experts Group (MPEG), a standard in accord with the International Organization for Standardization/ International Electro-technical Commission (ISO/IEC). Other compression technologies are the H.261, H.262 and H.263 standards of the International Telecommunications Union, Teleconferencing Section (ITU-T) for use in video teleconferencing, for example.

In conjunction with these image data formatting standards and techniques, by which the encoder 20 provides a syntax for the subsequent bitstream, the encoder 20 also employs compression algorithms, such as Discrete Cosine Transforms (DCT), Huffman coding and other mechanisms, whereby the amount of data needed to represent the image is drastically reduced while substantially retaining image integrity. As is well understood by those skilled in the art, these and other techniques eliminate or reduce the transmission of frame-to-frame redundancies and other information which are unnecessary or

repetitive, and exploit various physiological and psychological aspects of human perception to present a coherent image to the viewer's eye.

With further reference to FIGURE 1, the subsampler 18, encoder 20 and buffer 22 are controlled by a control unit 24, which also controls other functions of the imaging system 10. For example, control unit 24 controls the sequencing of the afore-described operations, i.e., image pickup by camera 14 through a connection thereto (not shown), pixel conversion in subsampler 18, compression in encoder 20, recording the encoded images on a magnetic or electronic recording medium (not shown), and other operations. Control unit 24 supplies encoder 20 with a plurality of operating parameters to govern the aforementioned transformation of pixel data into a corresponding compressed bitstream. As discussed, control unit 24 also governs the variable bit rate of the information flow into buffer 22 to maintain a particular data level and avoid both overflow and underflow therein.

As is understood in this art, the primary purpose of buffer 22 is to regulate the flow of data from the encoder 20 and forward that data at a fixed rate across a transmission channel 26 to a receiver device 28, particularly, to another buffer 30 therein, which like buffer 22 acts as a reservoir storing the data and regulating its use. It should, of course, be understood that channel 26 may transfer data at a variable rate, e.g., a variable rate service of an Asynchronous Transfer Mode (ATM) network. Nonetheless, the variable flow rate of data from encoder 20 does not generally agree with that of channel 26, fixed or variable.

Buffer 30 forwards the received image data, at a fixed or variable rate as needed, to a decoder 32. Similarly to the encoding process, the decoder 32 reverses the aforedescribed compression algorithms to expand the image pursuant to the aforementioned operating parameters. In other words, the decoder 32 decompresses the compressed information in the bit stream and reconstitutes the image pursuant to the relevant image format used, e.g., the ITU-R/601 Digital Studio Standard, and the operating parameters. The reconstituted image is then placed within an image storage device 34, the

contents of which may be continuously displayed on a video display 36, the circuitry of which is understood in the art.

As discussed, the aforedescribed compression technologies employ various techniques to condense the image information. The decoder 32 is configured to interpret the format and operating parameters by which the image information was encoded by encoder 20. As is understood in the art, much of the decoding process performed within the decoder 32 may be called "normative", i.e., fixed by the particular standard used, e.g., MPEG. Consequently, the decoder 32 readily recognizes these normative parts of a signal from encoder 20, i.e., how to interpret the transmitted bits in the bit stream.

In conventional apparatus employing the above technology, the aforementioned operating parameters are fixed within the video system 10. Usually, encoder 20 utilizes fixed spatial and temporal resolution values, which comports well with the requirements of buffer 22, guaranteeing a fixed-rate bitstream across transmission channel 26. Nonetheless, buffer 22 in an effort to maintain the transmission rate required by the channel 26 adjusts the quantization or distortion of the pertinent images. Quantization then becomes a function of the fullness of buffer 22, which, in turn, is a function of the complexity of the subject video images, i.e., how bit-consuming the images are during compression. Some encoders 20 have fixed spatial resolution only and the buffer 22 adjusts quantization and temporal resolution to maintain the constant bit-rate. The balance between quantization and temporal resolution is governed by a buffer regulation algorithm, as is understood in the art.

One problem with the above configuration, however, is that the aforementioned operating parameters may be unsuitable in certain circumstances, and the buffer regulation algorithm or other resolution balancing scheme may require adjustment to suit the needs of the human viewer who may have a different spatial/temporal resolution and distortion balance in mind. For example, some video applications may require higher temporal resolution at the cost of coarse quantization, e.g., video communication between deaf people

(sign language) who prefer high temporal resolution. Additionally, surveillance applications normally require higher spatial resolution and fine quantization at the cost of temporal resolution.

Further, with the growing rise of consumer use and proficiency in electronic imaging systems, sophisticated videographers want increasing control over the operating parameters and may make fine adjustments to the balance between spatial and temporal resolution and quantization for a multitude of other applications, fine tuning these parameters for objective or subjective effect.

With these operating parameters fixed, however, videographers or any other user of video apparatus having these immutable characteristics cannot make any adjustments to the apparatus and encoder 20 operates without any feedback from the viewer.

Accordingly, it is a first object of the present invention to provide the viewer with a means to adjust the aforementioned spatial and temporal resolutions and quantization variables to suit their individual needs.

It is more particular object of the present invention to provide a means of feedback from the viewer to the encoder, enabling the viewer to have increased flexibility over the aforementioned operating parameters.

SUMMARY OF THE INVENTION

The present invention is directed to an improvement in an imaging system and method for providing increased viewer control over the operating parameters of the imaging system. Viewer control is facilitated by including a backchannel within the imaging system, enabling the viewer to adjust the operating parameters, e.g., spatial and temporal resolution, and quantization, of the video transmission.

A more complete appreciation of the present invention and the scope thereof can be obtained from the accompanying drawings which are briefly summarized below, the following detailed description of the presently-preferred embodiments of the invention, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram illustrating a conventional electronic imaging system; and

FIGURE 2 is a block diagram illustrating an electronic imaging system in accordance with the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EXEMPLARY EMBODIMENTS

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

With reference now to FIGURE 2 of the drawings, there is illustrated an electronic imaging system, generally represented by the numeral 40, which incorporates the subject matter of the present invention. The imaging system 40 illustrated in FIGURE 2, as with the conventional imaging system 10 set forth in FIGURE 1, includes a sending device 42 which receives signals from a camera 44 which captures and records an optical image, such as the individual depicted. As discussed, the various portions of camera 44 that are not related to the present invention, are not illustrated. The optical image before camera 44 is received by a camera lens 46 and converted into a signal, as described. The aforementioned signal is then forwarded to a subsampler device 48, which determines pixel values representing the captured video image at a particular spatial resolution, i.e., pixels per line and lines per image, and temporal resolution, i.e., images per second. As discussed in connection with the imaging system 10 of FIGURE 1, an encoder 50 encodes the aforedescribed digital data into a video signal stream at particular spatial and temporal resolutions, which are fixed in conventional systems.

As with the sending device 12 of the conventional imaging system 10, sending device 42 includes a buffer 52 to receive the encoded, compressed video signal stream from the encoder 50, and a control unit 54 to control the operations of the converter 48, encoder 50 and buffer 52. As discussed, the control unit 54 supplies encoder 50 with the aforedescribed operating parameters to govern the data transformation. Whereas several parameters were fixed in the conventional system illustrated in FIGURE 1, e.g., the aforementioned spatial and temporal resolutions, a user of the video system 40 of the present invention is able to variably control these parameters, as will be discussed more fully hereinafter.

As with the conventional system, buffer 52 manages the variable flow of data from the encoder 50 and outputs a fixed-rate video data bit stream across a transmission channel 56 to a receiver device 58, particularly, to a buffer 60 therein, which like buffer 30 in FIGURE 1 receives the fixed flow of data and forwards it to a decoder 62. As with channel 26, it should be understood that channel 56 may permit variable data flow rates.

Similarly to the encoding process, the decoder 62 reverses the aforedescribed compression algorithms to expand the image pursuant to the aforementioned operating parameters. Decoder 62 decompresses the compressed and formatted information in the bit stream and reconstitutes the image pursuant to the relevant format and the operating parameters. The reconstituted image is then placed within an image storage device 64, the contents of which may be continuously displayed on a video display 66, which in FIGURE 2 displays the aforementioned individual.

As discussed, decoder 62 is configured to decode normative information from the encoder 50, i.e., the format, standard and operating parameters of the video data bitstream. It should, therefore, be understood that the decoder 62, as well as decoder 32, recognizes these normative parts of a signal from encoder 50, e.g., the particular video format used, e.g., the aforementioned ITU-R/601 standard, and the various compression standards, e.g., ISO/IEC MPEG-1, MPEG-2, and MPEG-4, and ITU-T H.261, H.262 and

H.263. Although decoder 62 is preferably of conventional design and therefore able to understand the pertinent normative communication signals, it should be understood that decoder 62 may also be configured to accept non-normative commands, i.e., commands or information outside the particular standard being used, as described hereinafter.

Since the encoder 50 (and the encoding process) is not specified within the aforementioned standards (all that matters is correct decoding), video system designers have a lot of freedom as to the implementation non-normative aspects of the technology. So long as the decoder 62 can understand the pertinent standards and is configured to decode the particular non-normative functions desired, numerous additional options may be implemented, such as in modifying picture quality, as will be discussed more fully hereinafter.

With reference again to FIGURE 2, receiving device 58 also includes a human interface device 68, through which many of the aforedescribed operating parameters may be adjusted, e.g., to modify image clarity (spatial resolution and quantization), frequency (temporal resolution or frame rate) and other characteristics. The human interface device 68, which may include a button, slide, keyboard or other conventional interface apparatus, forwards the indicated changes to a translator 70, which converts the changes to a signal. The aforedescribed signal is then sent back to the control unit 54 of the sending device 42 via a backchannel 72.

By means of the video system 40 configuration with backchannel 72 signaling capability, the viewer may through interface 68 interactively modify various operational parameters, such as those defining image quality. For example, the following operational parameters may be implemented in the video system 40 of the present invention to regulate image quality:

(a) high/low spatial resolution (image detail),

(b) high/low temporal resolution (frame rate),

(c) high/low quantization (image distortion),

(d) balance between (a) and (b),

(e) balance between (a) and (c), and

(f) balance between (b) and (c).

It should be understood that, whereas the conventional video system 10 employs fixed (a), (b) and (c) operational parameters, the video system 40 of the present invention permits alteration of the balance between these operational parameters. In the conventional video system 10, if either (a) or (b) were changed, then the amount of distortion (c) must be adjusted to achieve the requisite bit rate. Accordingly, selecting (a) is equivalent to selecting (e), a balance between spatial resolution and quantization. Similarly, selecting (b) is equivalent to selecting (f), a balance between temporal resolution and quantization. It should also be understood that selecting (c) is also equivalent to selecting (f) since an encoder typically does not alter its spatial resolution but may easily adjust temporal resolution. As discussed, the viewer may want a different image resolution balance than that presently in use, i.e., either the aforementioned predetermined balance or a previously selected balance, and want to adjust the operational parameter settings to achieve a desired balance. Through interaction with the human interface 68, e.g., by pressing or turning a button 74 (constituting interface 68 or connected thereto via a connection 75) on the display device 74 or a like button 76 on a remote device 78 also shown in FIGURE 2, the translator 70 may forward a particular codeword or other indicia indicating the particular command corresponding thereto back to the encoder 50, which adjusts its operations accordingly. For example, the viewer may forward the commands "A+" to increase spatial resolution, "B-" to decrease temporal resolution, "F+" to decrease distortion, etc. It should, of course, be understood that the above commands are exemplary only, and other symbols may be utilized by the video system 40 to implement the viewer's desired changes. In any event, the bitstream after adjustment should reflect the indicated change.

Additionally, a request for a new balance between temporal resolution and coding distortion may be sent from translator 70 via backchannel 72 as "q<k>", where "q" represents the type of command requested and "<k>" indicates a particular value for that command. It should be understood that "k"

is preferably within a predefined discrete range of permissible values. Since the number of permissible resolutions is rather large in the aforementioned compression standards, e.g., MPEG-1, MPEG-2, ITU-T H.261 and others, the range of resolutions in a specific implementation is preferably specified and is governed by the capabilities of the particular camera (14 or 44) and subsampler (18 or 48) used. Alternatively, it may be useful to limit the numbers of such resolutions to a small set, assigning each a unique code. Temporal resolution may likewise be designated within a discrete range of values, albeit there may be constraints to multiples of the minimum frame period, e.g., 1/30th of a second. Quantization, typically within the purview of the equipment manufacturers, may likewise be selected within a range, e.g., supplied by the particular manufacturer. In this manner, it should further be understood that the encoder 50, upon receipt of a given codeword such as "q", may set a plurality of internal parameters accordingly. Similarly, various internal parameters of buffer 52 may also be set.

Further, the particular viewer request transmitted through the backchannel 72 may be defined to be valid in a number of different ways, including:

(A) forever, until a new request is given;

(B) for a limited time period, namely x seconds, where x is pre-defined;

(C) for a limited number of n images, where n is predefined;

(D) as long as a transmitted codeword "x" indicates; and

(E) as many images as a transmitted codeword "n" indicates.

For example, a user may request a very high spatial resolution image, which may constitute a high resolution still image, by pressing button 74 (or button 76 on remote 78), which causes the translator 70 to generate a specific codeword, e.g., "s" for still, which would be defined to be valid for a single image (n=1 for option C above). The entire command transmitted across backchannel 72 would then be "sC1". Also, "g3A" may indicate a quantization level 3 from now on, and "t1B5" would similarly be temporal resolution level 1 for 5 seconds.

In view of the above description, it should be understood that a wide variety of non-normative commands may be utilized by a viewer to customize video images for various usages.

Further details of the still picture management aspects of the video system 40 configuration of the present invention may be found in Applicants' co-pending patent application, entitled "Method and Apparatus for Still Picture Transmission and Display", filed concurrently herewith and incorporated herein by reference.

It should be understood that the aforedescribed principles of the present invention may also be applied in other contexts, such as video conferencing, whereby a viewer may adapt the received signal to suit their needs. For example, if identification of individuals or objects is important, then an increase in spatial resolution and finer quantization (less distortion) is in order at the expense of temporal resolution. If image continuity is important, then sacrifices may be made in spatial resolution and distortion to achieve temporal stability. Other variations, such as taking a still image of a remote participant or fine-tuning the received image for further applications, should be considered to be within the purview of the present description.

It should be understood that sending device 42 may be resident within camera 44 and receiving device 58 may be resident within the display device 66, such as in conventional video systems. It should, nonetheless, be understood that both the sending 42 and receiving 58 devices may instead be incorporated within multifunction terminals, e.g., as a video-capable mobile transmitter/receiver, implemented in software (with the requisite hardware components such as the interface 69) within a general computer, implemented as separate equipment boxes with input and output connectors, or included (at least at the receiving end) as part of a value-added-service network, i.e., a network shared resource.

It should further be understood that control unit 54 shown in FIGURE 2 may also control operations of the camera 44 through a connection thereto

(not shown). In this manner, the camera zoom, pan, tilt, iris and other camera functions may be user controlled because of backchannel 72.

The previous description is of preferred embodiments for implementing the invention, and the scope of the invention should not necessarily be limited by this description. The scope of the present invention is instead defined by the following claims.

WHAT IS CLAIMED IS:

1. An imaging system for receiving, processing and displaying a multiplicity of images, said imaging system comprising:

a sending means, connected to a camera means, for receiving said multiplicity of images therefrom;

a processing means, within said sending means, for processing said multiplicity of images and generating a digital signal corresponding to said multiplicity of images, said digital signal comprising a plurality of operating parameters;

a receiving means, connected to said sending means and said processing means via a forward channel, for receiving said digital signal for said multiplicity of images;

a decoding means, within said receiving means, for decoding said digital signal and reconstituting said multiplicity of images therefrom pursuant to said plurality of operating parameters;

a display for displaying said multiplicity of images from said receiving means; and

an interface, connected to said receiving means, said interface, in response to a command to modify at least one of said operating parameters, forwarding said command to said processing means within said sending means via a backchannel thereto, whereby said processing means modifies said digital signal.

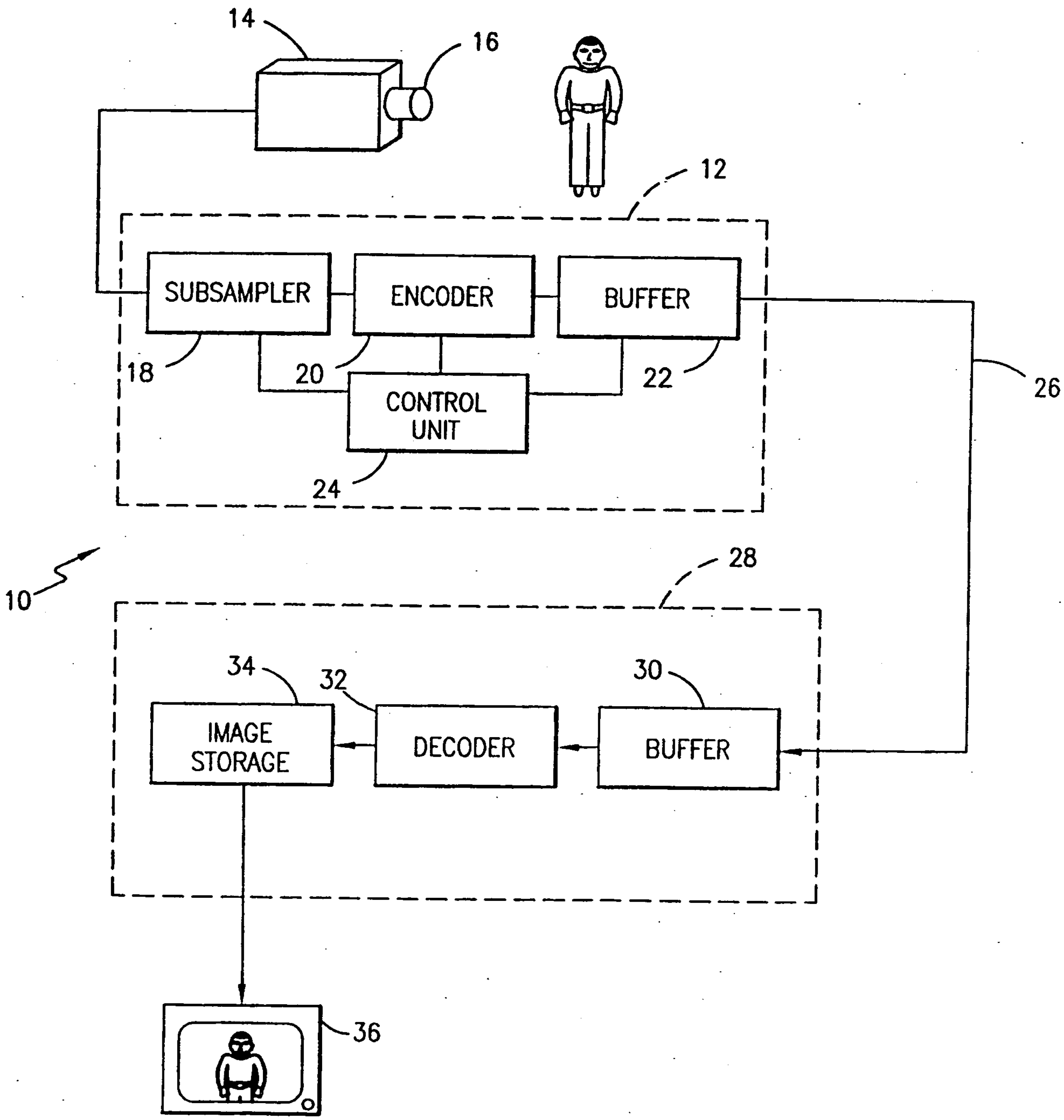
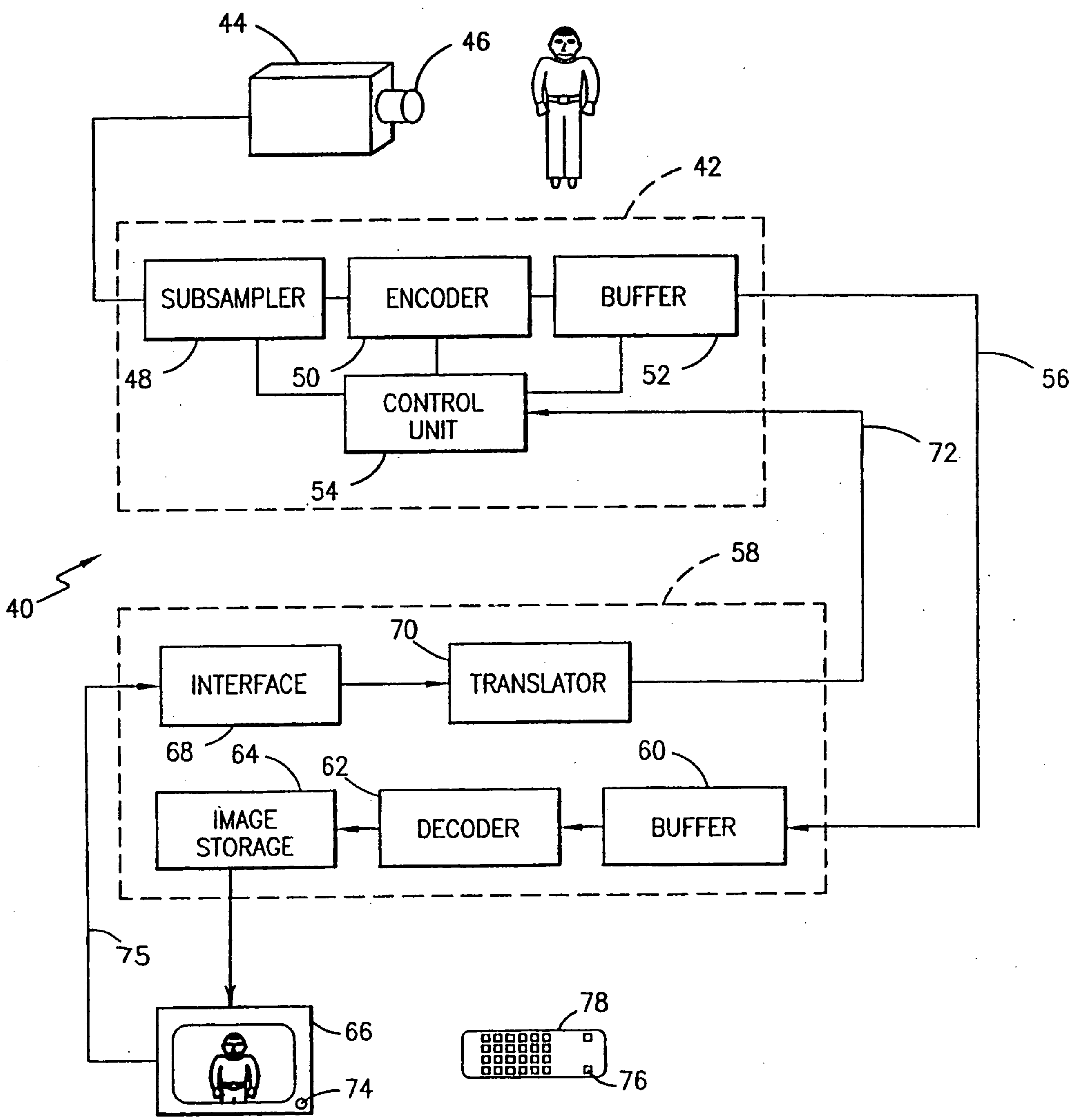


FIG. 1 PRIOR ART


44
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SUBSAMPLER
ENCODER
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CONTROL UNIT
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INTERFACE
TRANSLATOR
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IMAGE STORAGE
DECODER
BUFFER
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FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 98/00394

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04N7/14 H04N7/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 94 03014 A (KOZ MARK C ;HATA MASATO (JP)) 3 February 1994 see page 3, line 21 - page 4, line 8 see page 5, line 24 - page 6, line 2 see page 8, line 26 - page 9, line 36 see page 11, line 35 - page 13, line 11 see figures 1,2 ---	1
A	US 5 598 456 A (FEINBERG) 28 January 1997 see column 4, line 13 - line 42 see column 10, line 38 - column 11, line 2 -----	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
11 May 1998	20/05/1998

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/SE 98/00394

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